SPECIFICATION

Electronic Version 1.2.8

Stylesheet Version 1.0

AUDIO NOISE CANCELLATION SYSTEM FOR A SENSOR IN AN AUTOMOTIVE VEHICLE

Background of Invention

[0001] The present invention relates generally to a compensation circuit for automotive sensors, and more particularly, to a circuit to compensate the output of a sensor for noise generated by an audio system.

[0002] Sensors are used for various applications in automotive vehicles. Sensors may be located in various locations such as the passenger compartment.

[0003] Audio systems include various speakers including a subwoofer. The subwoofer is large and difficult to package. As such, the subwoofer may be positioned in a close proximity to a sensor.

[0004] The output of the speaker and, in particular, the output of a subwoofer is a low frequency, high-power signal that generates acoustic energy that may affect the output of the sensor. In particular, the output of the sensor may vibrate or move in response to the output of the subwoofer.

[0005] One proposed solution to compensation is to use a microphone that receives signals from the speaker and converts the signals to electrical signals. However, interference from the subwoofer body may be present due to the location of the microphone. Thus, the circuit may be very accurate. Also, flexibility of packaging a microphone near the subwoofer presents difficulties particularly in the limited automotive vehicle package spaces.

[0006] It would therefore be desirable to remove the influence of the subwoofer on the

output of the sensor.

Summary of Invention

[0007] The present invention reduces the influence of the subwoofer on the output of a sensor from prior known methods. In one aspect of the invention a compensation circuit for a sensor generating electrical sensor output is positioned near a speaker of an audio system and comprises an inverting circuit electrically coupled to the electrical output of the audio system. The inverting circuit generates an inverted electrical signal corresponding to a speaker audio output. A sensor controller is coupled to the inverting circuit and the sensor. The controller generates a compensated electrical output in response to the electrical sensor output and the inverted electrical signal.

[0008] In a further aspect of the invention, a method for compensating for an electrical output of a sensor comprises generating an electrical signal at an audio system output and electrical input to a speaker; inverting the electrical signal to form an inverted electrical signal; generating an electrical sensor output signal altered by the acoustics of the speaker; and combining the inverted electrical signal and sensor output signal to form a compensated electrical output.

[0009] One advantage of the invention is that the various sensors may be packaged without regard to the location of the speakers of the audio system. Such a system will therefore increase package flexibility in the limiting packaging space of the automotive vehicle.

[0010] Other advantages and features of the present invention will become apparent when viewed in light of the detailed description of the preferred embodiment when taken in conjunction with the attached drawings and appended claims.

Brief Description of Drawings

[0011] Figure 1 is a schematic view of a compensation circuit according to the present invention.

[0012] Figure 2 is a plot of a normal sensor output.

[0013] Figure 3 is a plot of the output of the subwoofer.

[0014] Figure 4 is a plot of sensor output that has been affected by the output of a subwoofer.

Detailed Description

[0015] The present invention is described with respect to a sensor and subwoofer positioned in a passenger compartment of an automotive vehicle. The present invention may also be used for sensors positioned within the trunk compartment, engine compartment, or various other locations within the automotive vehicle.

[0016] Referring now to Figure 1, a passenger compartment 10 of an automotive vehicle is illustrated having a compensation circuit 12 according to the present invention. The compensation circuit is electrically coupled to an audio system 14. Compensation circuit 12 is preferably coupled to an electrical output 16 of the audio system 14. The electrical output 16 is used to electrically power a speaker 18. Speaker 18 may, for example, be a subwoofer or other type of speaker. The electrical signal from the audio system generated by electrical output 16 is used to drive a transducer coil within speaker 18. The speaker 18 generates audible sound signals 20 which may be received and influence a sensor 22. Thus, the electrical signal corresponds to eventual output of the speaker. Sensor 22 may be one of a variety of types of sensors including a pressure sensor. Thus, the output of the pressure sensor 22 is changed according to the audible signals 20 generated by speaker 18. Sensor 22 is coupled to a sensor controller 24. Controller 24 is preferably microprocessor-based. However, analog and or digital circuitry may also act as a controller.

[0017]

Compensation circuit 12 includes an inverting circuit 26 that has an input 28 coupled to the electrical output 16 of audio system 14 and therefore to the input of speaker 16. To filter out any DC offset, capacitor C_1 may be employed. Capacitor C_1 is coupled to input 28 and to a resistor R_1. Resistor R_1 is coupled between capacitor C_1 and the inverting terminal 30 of an operational amplifier 32. Inverting terminal 30 of operational amplifier 32 may also be coupled to a feedback resistor R_2 which in turn is coupled to an output 34 of operational amplifier 32. Operational amplifier 32 may also have a non-inverting terminal 36 coupled to a resistor R_3 which in turn is

coupled to a reference voltage

$\frac{V_{cc}}{2}$

. By properly choosing the resistance values of R_1, R_2, and R_3, an inverted electrical signal is generated at output 34. In one constructed embodiment, the resistors R_1 R_2 R_3 are equal to obtain unity gain and was set to R1/2. By way of example, R_1 and R_2 may be 100k ohms and R_3 may be 50K ohms. The capacitor is sized to block DC offset and thus depends on the input to which it is attached. Capacitor C_1 may, for example, be luF. Of course, the resistor values may be chosen to amplify the signals as well. Output 34 may be electrically coupled to a delay circuit 40. Delay circuit 40 is an optional feature that is used to align the inverting signal temporally with the output of the sensor. Various types of circuits may be used for delay circuit 40. Such circuits are well known to those skilled in the art. The delay circuit generates a delay signal that is added to the inverted electrical signal from the output 34 of operational amplifier 32. The delayed inverted output signal is coupled to controller 24. Controller 24 combines the inverted electrical signal and the sensor output signal to form a compensated output signal at an output 42 of controller 24. Of course, controller 24 may also use the compensated signal therein. Controller 24 may merely add the two signals together to form the compensated electrical output.Referring now to Figure 2, a plot of the normal sensor output versus time is illustrated.In Figure 3 the subwoofer output versus time is illustrated. This signal is the electrical output of the audio system.Figure 4 includes the sensor output that has been affected by the subwoofer output. When the electrical output of the audio system is inverted and added to Figure 4, the compensated output signal of the present invention is thus similar to that of Figure 2.Advantageously, the present invention does not rely on the positioning of a microphone or other transducer device directly adjacent to the speaker. Thus, for automotive applications increased flexibility is achieved in applying the compensation circuit of the present invention.While particular embodiments of the invention have been shown and described, numerous variations and alternate embodiments will occur to those skilled in the art. Accordingly, it is intended that the invention be limited only in terms of the appended claims.